NOMINATION FOR REGISTRATION AND RELEASE OF FOUR MULTI-PURPOSE CASSAVA VARIETIES FOR FOOD SECURITY (HOPE AND BABA-70) AND INDUSTRY (GAME CHANGER AND OBASANJO-2) PRODUCT PROFILES IN NIGERIA

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1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) being a principal staple food crop, has also attained the status of a major industrial and income-earning crop across sub-Saharan Africa (SSA). A large proportion of the population in Africa and Nigeria depends on cassava for their sustenance and income along the cassava value chains (Lamboll et al. 2015). In the age of rapid industrial growth and innovation, the rising demand for cassava as a raw material offers enormous opportunities for better livelihoods and enhanced incomes. Furthermore, regional bodies (IFAD and ECOWAS) and national governments have recognized cassava as a key strategic crop, offering the crop a favorable legal and policy framework. For example, a 10% inclusion of cassava flour in baking and flour milling industry led to increased demand for high-quality cassava flour in Nigeria (Nweke 2004). This policy adjustment resulted into creation of a demand for 1.5 million MT of fresh cassava roots in Nigeria (Nweke et al. 2002; Naoko Koyama, Jeff Kaiser, Kabura Ciugu 2015). Hence, cassava maintains excellent potential to compete with most cereal crops in the face of climate change and ageing soils. Increasing threats due to climate change will negatively disrupt output levels of several cereal and legume grains across Africa will less expected impacts for cassava. Cassava is also a key import substitution crop in Africa as the continent seeks to be self-sufficient in food production.

The Next Generation Cassava Breeding project (www.nextgencassava.org) was initiated to develop a new generation of varieties that address the needs of both food security and industry. The new varieties proposed here utilized new breeding tools that enhance the speed and efficiency of cassava breeding including use of genomic selection, use of digital tools for all data collection, data management using an open access database (cassavabase.org), and increased use of end-user product evaluation to ensure new varieties meet farmer, processor and consumer needs. Cassava breeding is also now linked to the developing formal seed system under the supervision of NASC to ensure the generation of the quantity and quality of commercial seed that will ensure access to the new varieties. We have developed new hybrid clones selected for combined high yield, high starch and dry matter content (DMC) as well as

required CMD resistance. These varieties also possess good processing product attributes for gari and fufu. These traits constitute key driving factors in Nigeria's cassava processing industry. They have a high potential of sustainably boosting production levels of these emerging industries and new markets. Fresh cassava and its derived products are not only crucial as industrial raw material but also vital for both human and animal nutrition (Nweke 2004). Notably, women and youth will greatly benefit from these new cassava varieties since they play critical roles in the cassava value chain. One key effort of the breeding teams of the NextGen Cassava project at NRCRI and IITA was the development of product profiles for cassava varieties and this includes varieties that address gari and fufu markets, boiled/poundable cassava, biofortified cassava and cassava for industry (Table 1). Our aim is to ensure that varieties were developed to address each of these markets. While varieties HOPE and BABA-70 address the gari and fufu markets, varieties GAME CHANGER and OBASANJO-2 target the industrial sector for utilization in the starch and flour industry.

The clones presented here for release have the potential to replace old varieties for processed products that that been earlier released and disseminated. Ultimately, this novel set of varieties will accelerate the attainment of the the Federal Government's Cassava Transformation Agenda in Nigeria. These clones have been widely evaluated across major agro-ecologies in Nigeria.

2. MULTI-LOCATIONAL TRIALS

2.1. Materials and methods

The varieties presented here for registration and release in this dossier were derived from hybrids produced among 88 elite IITA genetic gain (GG) population clones that were used as parents based on DNA analysis and prediction of genomic estimated breeding values. In a first cycle of genomic recurrent selection, 2,323 genotypes out of the 20,000 full-sib hybrid progenies were evaluated and selected in clonal evaluation trials (CET) at three locations, Mokwa, Ikenne and Ibadan. From the CET, 562 elite genotypes were advanced through preliminary yield trials (PYT) and 82 clones were selected for advanced yield trials (AYT) by phenotypic selection. Selection decisions at each advancement stage were made based on a selection index that included key traits that define our product profiles. These traits include fresh root yield (FYLD), dry matter content (DMC), harvest index (HI), mean cassava mosaic disease severity (CMD) and plant height. Highly heritable traits were weighed heavily in the early selection stages relative to the lower heritability traits that weight heavily in advanced selection stages.

2.1.1. Uniform Yield Trials (UYT)

UYTs were evaluated during the 2016/2017 cropping season. An advancement decision resulted into selection of 28 promising clones from AYT for UYT level testing. Together with 5 national check varieties, the clones were evaluated in 4 locations, Ubiaja, Ikenne, Mokwa, and Umudike. Advancement of clones from UYT to the National Coordinated Research Project (NCRP) trials were also guided by a selection index, trial heritability estimates, genetic variances and coefficients of variation (CV). Heavier selection index weights were assigned to DMC, percentage of processed products (Gari and Fufu), DYLD, FRY and HI. For the genotypes assessed at NRCRI, their performance at UYT at Umudike is indicated in Table 2.

2.1.2. Nationally Coordinated Research Project (NCRP)

In the 2017/2018 and 2018/2019 cropping seasons, 18 varieties were nominated for testing through the National Coordinated Research Project (NCRP) as shown in 3. These varieties were evaluated across nine locations including Ago-Owu, Ikenne, Abuja, Igbariam, Mokwa, Ubiaja, Umudike and Zaria. All field evaluations at UYT and NCRP used randomized complete block designs (RCBD) with three replications. Each plot was phenotyped for their reaction to major diseases and pests including; cassava mosaic disease (CMD), cassava bacterial blight (CBB) and cassava green mite disease (CGM). Yield related data include; DMC, starch percentage, gari percentage, fufu percentage, FYLD, and mean number of roots were taken 12 months after planting. To estimate DMC, 100g of grated fresh roots per plot were oven dried at 65^{o}C for 72 hours until a constant weight was attained. Upon cooling dried weight was determined(Matete Benesi 2005). For distant off-station trials, the specific gravity method was used to determine DMC (Fukuda et al. 2010; Teye and Asare, 2011).

To estimate starch percentage the wet method was used where 100 g of homogenized fresh roots per plot were washed, peeled and pulverized in a blender following a standard method described by Benesi (2005). The filtrate was allowed to settle and the top liquid was poured off leaving the sediment starch to be dried and packed for weighing. To estimate gari and fufu percentage, fresh root samples of 5 to 10 kg per plot in each single location were processed to produced gari and fufu following a standard processing protocol (Nweke et al. 2002).

2.1.3. Data Analysis

2.1.3.1. Single Trial Analysis

For each individual trial, we fitted the linear mixed model using the lme4 R package (Bates et al. 2017) as follows:

$$Trait = \mu + g + r + \varepsilon$$

where g and r is the genotype and replication effect respectively.

Entry-mean basis heritability (H_m^2) was calculated following the equation:

$$H_m^2 = \frac{\sigma_g^2}{\sigma_g^2 + \frac{\sigma_e^2}{n}},$$

Where; σ_g^2 is the genetic variance, σ_e^2 is the error variance and n is the number of replications.

2.1.3.2. Multi-Environment Trial Analysis

We collapsed plot observations for each genotype to single best linear unbiased estimates (BLUEs) using the following mixed linear model (MLM) with the lme4 (Bates et al. 2017) package in R: $y_{ij} = \mu + g_i + \beta_j + r_{j(l)} + \varepsilon_{ijl}$ where y_{ij} represents the vector of phenotype data, μ is the grand mean, g_i is the fixed effect of genotype i, β_j are the random effects of year-location combination *j* distributed $\beta_j \sim N(0, \sigma_\beta^2)$, $r_{j(l)}$ is a random effect of replication nested within location-year combination assumed to be distributed $N(0, \sigma_r^2)$; and ε_{ijl} is the residual with $\varepsilon_{ijl} \sim N(0, \sigma_e^2)$.

We calculated broad-sense heritability estimates on a **plot-mean basis** using the formula

$$H_p^2 = \frac{\sigma_g^2}{\sigma_g^2 + \sigma_e^2}.$$

2.1.3.3. Analysis of genotype by environment (GxE) interaction in the NCRP trials

To assess the genotype by environment interactions for the 18 clones the NCRP trials, we used the GGE (genotype main effect and genotype by environment interaction) linear-bilinear model and results were visualized using GGE biplot (Yan and Kang 2002). The GGE model was:

$$Y_{ij} - \mu - \beta_i = \lambda_1 \xi_{i1} \eta_{j1} + \lambda_2 \xi_{i2} \eta_{j2} + \varepsilon_{ij}$$

Where Y_{ij} is is measured mean of genotype i in environment j, μ is the grand mean, β_i is the main effect of the environment j, λ_1 and λ_2 are the singular values in the first and second principal components (PC1 and PC2), respectively, ξ_{i1} and ξ_{i2} are eigenvectors for genotype i for PC1 and PC2, respectively, η_{j1} and η_{j1} are eigenvectors of environment j for PC1 and PC2, respectively, ε_{ij} is the residual associated with genotype i in environment j. In this analysis, we mainly focused on fresh root yield and dry matter percentage to enable selection of stable and superior genotypes for advancement. The best genotypes were selected such that if the angle between the genotype and related sets of environments are less than 90°.

3. Results and Discussion

3.1.1. Advancement from first clonal evaluation to Pre-NCRP.

A joint analysis of early, intermediate and late stage trials was done using a linear mixed model (MLM) incorporating the effect of trial and experimental design effect to obtain single Best Linear Estimates (BLUEs also known as adjusted means). For both traits (log rtwt, and DMC) most of the clones that reached late testing stages showed superior performance as depicted in Figure 1.

3.1.2. Uniform Yield Trials (UYT)

UYT trials are presented under this section. In order to assess the trial quality for these UYTs, we calculated broad-sense heritability (H^2) estimates on an entry mean-basis for all the UYT trials across four states in 2017. For example, moderate to high heritability values were obtained for UYT's conducted by IITA (Table 4). For mean CMD severity (CMD) heritability ranged from 0.85 to 0.98 while the values for DMC ranged from 0.56 to 0.90. Heritability for FYLD ranged from 0.56 in Ubiaja to 0.75 in Ikenne while heritability for dry root yield (DYLD) ranged from 0.44 in Ubiaja to 0.76 for Mokwa.

Summary results of the UYT trials is presented as Best Linear Unbiased Estimates (BLUES) which is analogous to adjusted means. The performance of 34 clones (28 entries and 6 checks) were tested across the 4 environments are presented in Table 5. The mean FYLD was 35 t/ha ranging from 23 to 37 t/ha while DMC ranged between 30 to 39% across locations. Majority of the clones were resistant to CMD across all the testing sites with mean CMD severity score of 1 except for 3 clones with mean score 3. The other key traits considered were percentage gari and fufu (dry weight / fresh root weight basis). Gari yield ranged from 17 (IITA-TMS-IBA30572) to 27% (TMS13F1160P0004). Fufu yield ranged from 15 to 24% while the percentage fibre residue from fufu processing ranged from as low as 0.1 in clone

TMS13F1160P0004 to as high 17 in clone TMS12F1365P0002. Such clones with high fiber content are not desirable for fufu production. We used a selection index (FYLD*20 + DMC*20 – CMD*10) to rank the clones and advance a subset to NCRP trials. In addition to the selection index value, we also considered gari percentage, fufu percentage, and general plant architecture to select 15 clones for NCRP testing (Table 5).

A number of high yielding clones were not considered for NCRP trials due to some undesirable characteristics like susceptibility to CMD, short plant stature, low DMC and poor processing qualities such as low percentage of Gari and in some cases high fufu fiber content (Table 5).

3.1.3. National Coordinated Research Project (NCRP)

In the following section, we describe the results of the multi-environment NCRP trials analysis. The heritability estimates and associated genetic and error variances for each NCRP trial for selected traits are presented in (Table 6). For mean CMD severity (CMD) the values ranged from 0.54 to 0.99 while the values for dry matter content (DM) ranged from 0.64 to 0.94. Heritability for fresh root yield (FYLD) ranged from 0.42 in Ago Owu to 0.91 in Umudike. We also obtained good H^2 estimates for gari (0.69 – 0.96) and starch percentage (0.79 – 0.94). The mean coefficient of variation (CV) ranged from 5 for DM to 34 for FYLD. The trait DM generally had lowest CV. These high heritability estimates are a good indication of good trial management and ability to evaluate these specific traits.

The mean and variance of the NCRP trials for FYLD and DMC are presented as boxplots across trials (Figure 2). The mean FYLD ranged from 20 in Ikenne in 2019 to 30 t/ha in Ago-Owu in 2019. Within each trial we observed considerable variation as indicated by the boxplots. The mean DMC by trial was in the range of 31 to 37%. The trial with the lowest DMC was Mokwa 2019 and the highest in Igbariam 2019.

The tables of genotype by environment adjusted means (BLUEs) for FYLD, DMC, as well as percentage gari, fufu, starch content and MCMDS are presented Tables 7 to 12.

The adjusted means were calculated from three within environment replicates by fitting the following linear mixed model:

$$\text{Trait} = \text{grand mean} + \text{clone} + \text{Rep} + \text{Residual}$$

where clone effects were considered as fixed effect.

Average FYLD for the different environments ranged from 14.8 to 20 t/ha while the average values for clones across environments ranged from 16.6 (farmer local) to 30 t/ha (NR130124) (Table 7). Six varieties recorded mean FYLD greater than 25 t/ha and majority of them

performed better than TMS-IBA30572 and TMEB419, two of the most widely grown old improved and new improved varieties, respectively.

Dry matter data presented in Table 8 depicts varietal performance of 18 clones across the testing locations. The candidate varieties recorded consistently higher DMC percentages compared to the national check, TMEB419 and the local best varieties. With regards to DMC, the candidate varieties, TMS13F1160P0004, TMS13F1343P0022, NR130124, and TMS-IBA000070, outperformed or were similar to the popular TMEB419. Dry yield is a product of the fresh root yield and dry matter content and it gives a direct value of the variety product yield. The candidate varieties out-yielded the check varieties (Table 9).

Besides FYLD, DYLD and DMC, we also phenotyped the NCRP clones for key root quality traits, namely gari and fufu in 3 and 2 locations, respectively. The results for gari from Ikenne (2018), Ago-Owu (2019) and Ikenne (2019) are presented in Table 10.

The performance of the candidate clones was comparable to that of the popular released commercial variety TMEB419 across locations. Average gari content of the different clones across locations ranged from 13 to 24 %. The leading clones includes TMS13F1160P0004 and TMS13F1343P0022.

The average fufu percentage for the two locations was similar (22%) (Table 11). The clones with high fufu % included TMS13F1160P0004, TMS13F1343P0022 and TMS13F1307P006. However, the difference between the high and low fufu was 6% overall indicating most had acceptable conversion rates.

Starch content per environment ranged from 25.33 to 28.7% and for clones it ranged from 20.98 to 32.89 (Table 12). Clones with high starch content include TMS13F1160P0004 (32.9%), TMS13F1053P0015 (30.3%), TMS13F1307P0016 (28.99%) and TMS13F1343P0022 (28.58%). The first clone was leading in starch % across all three locations and outperformed industry-preferred variety for starch, TMEB419.

The response of the varieties to the major pests and disease of cassava in Nigeria, CMD, and indicated a high resistance response to the biotic stress across environments (Table 13-15). There were observed high interaction between environments (Table 16).

Results of the GGE analysis for FYLD, DM and DYLD are presented in **Error! Reference source not found.**. The first two PCs accounted for 70.8 and 79.6 % of the GxE interaction for FYLD and DMC, respectively. Most the environments were correlated for FYLD with the exception of 19NCRPIGB (Igbariam, 2019) and 19NCRPAB (Abuja, 2019). The most adapted genotyped to these locations include TMEB419 for the former and IITA-TMS-IBA000070. Clone NR130124 performed well in the major mega-environment followed by clones

TMS13F1160P0004 and TMS13F1343P0022. Poor performing clones for FYLD include the local checks suggesting that the improved varieties perform better or are more broadly adapted across the testing sites used in the evaluation.

For dry matter percentage, all environments clustered within one mega-environment (Figure 3) Clone TMS13F1160P0004 performed well across all the environments for this trait followed by TMS13F1343P0022 and TMS13F1052P0015. Since DMC and starch content are highly correlated in cassava, it is expected that clones with high DMC % will also have high starch %. The 4 clones demonstrated a high dry yield.

4. ON-FARM TRIALS

4.1. Materials and methods

Following multi-location testing across nine locations at NCRP level, six clones were nominated for on-farm testing and evaluation and these included; IITA-TMS-IBA00070, NR130124, TMS13F1160P0004, TMS13F1307P0016 and TMS13F1343P0022, were nominated for on-farm evaluation trials across 10 states (Table 17). These candidate clones exhibited a good level of stability across locations during the NCRP evaluations during the 2018/2019 cropping season. One commercial released variety, TMEB419 was selected for evaluation along with the six nominated candidate varieties. Also, included in the evaluation was a local best variety that was specific for each location.

All on-farm trials were conducted using randomized complete block designs (RCBD) with each on-farm trial representing a replicate per state – which was considered as an individual trial.

4.2. Proximate Analysis

After harvesting each on-farm trial, fresh laboratory root samples were collected from each and every plot and submitted to the crop utilization and food quality laboratory at IITA for proximate analyses. All the samples from the six clones were well cleaned and packaged for futher laboratory assessment.

To determine proximate dry matter content (DMC), an approved method (925.09) of the Association of Official Analytical Chemists (AOAC) was followed using ten grams of fresh root sample. The samples were oven dried for 16 h at 105 °C till until attainment of a constant. In bid to estimate the mineral content of the root samples, the ash content was determined according to method 923.03 of the AOAC. Fresh root samples were converted into cassava flour which was used to estimate the ash content of the root samples. Three grams of flour were

carbonized in the Muffle furnace at 500℃ for 6 hours. Proximate ash content was determined following the following method;

$$\%Ash = \frac{\text{Weight of cassava flour before ashing – weight of ash}}{\text{Weight before ashing}} * 100$$

Also, to estimate the tuber proximate starch content, reducing sugars, amylose and amylopectin the AOAC (1990) methods and procedures were followed while hydrogen cyanide content (HCN) per 100 grams was determined following a method described by both Fukuda et al. (2010) and Grace (1977).

4.3. Basis for selection of Varieties for Registration and Release.

1.1. Results and Discussion

Results recorded from on-farm evaluations indicated that the candidate varieties outperformed the national check although in some cases similar performance was recorded especially for FYLD across location (Table 18). Variety IITA-TMS-IBA00070 recorded outstanding FYLD performance across the nine states with FYLD greater than 25 t/ha relative to both the local best variety and the national commercial variety TMEB419.

Based on farmers' overall acceptability and ranking of these varieties; variety TMS13F1160P0004 was consistently ranked highest across all states as the best clone relative to the local best that was rated worst.

On-farm assessment of the candidate varieties for DMC across the states is represented in Table 19. A consistent trend in clonal performance across states in farmers' fields was observed for TMS13F1160P0004, TMS13F1343P0022 and TMS13F1343P0044. These clones recorded similar or slightly higher DMC values in comparison to the local best as well as the commercial check variety TMEB419. It's important to report that in accordance to farmers' overall qualitative assessment, clones TMS13F1160P0004 and TMS13F1343P0022 were rated highest in relation to DMC.

The acceptability of food quality attributes for gari and fufu of the candidate varieties as per farmers assessment is presented in Table 20 and Table 21. Overall assessment of gari and fufu quality and quantity was done in order to get qualitative assessment of the food quality attributes of our candidate clones from a farmers' perspective and estimates as shown in Figure 5 indicate that these varieties were preferred for varieties.

Our candidate varieties were more preferred over the national or local checks for the gari and fufu products. Our observations indicated that the local best clones were consistently selected as very good after all the candidate varieties. This gives an indication of the potential

acceptability and adoption of our candidate varieties as substitutes or replacement for high gari and fufu cassava varieties. The distinctive characteristics of the candidate varieties are shown in Table 22 and Table 23.

We hereby recommend the naming, registration and release of UMUCASS 47, 48, 49 and 50 as multi-purpose cassava varieties for Nigerian cassava growers.

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Table 1. Cassava product profiles

SN		Key Trait	Required Trait	Target Level
1	Gari and Fufu (granulated and paste products)	Yield, high dry matter & processed product quality (colour and texture)	CMD, CBSD and whitefly resistance, flexible time of harvest	Dry matter content >35% with high processed product yield
2	Cassava for Fresh Markets	Yield, root mealiness, poundable, end-user preference	CMD, CBSD and whitefly resistance, drought tolerance, low CNP potential	Mealiness score 3 all seasons
3	Biofortified cassava for enhanced nutrition	Yield, β-carotene, suitability for gari and fufu	CMD, CBSD and whitefly resistance, low CNP potential	β-carotene content >15ppm fresh weight, Dry mater content >30%
4	Cassava for industry	Yield, high starch and flour content	CMD, CBSD and whitefly resistance, suitability for mechanization	Starch content >25%

Table 2: Performance of NRCRI clones in a UYT at Umudike in 2016/2017

Genotype	CMD*	CBB*	CGM*	Plant type#	Plant height	No. of Roots	FYLD	DMC
TME419	2	2	2	4	2.3	57	36.2	38.5
TMS30572	2	2	3	3	2.1	56	26.2	36.5
NR130022	1	1	3	4	2.2	53	22.9	35.3
NR130114	1	2	2	3	1.8	55	28.8	29.6
NR130124	1	1	3	4	2.1	50	23.4	35.2
NR130081	2	2	2	3	2.4	26	15.9	31.9
NR130143	3	1	4	3	1.4	47	21.5	27.9
NR130093	2	2	3	3	1.8	34	16.2	27.7
NR130036	2	2	2	2	1.7	36	20	35.9
NR130121	1	1	2	1	1.3	76	37.4	33.3
NR130120	1	1	3	1	1.9	36	24.6	29.9
NR130171	3	2	3	2	1.6	73	26	25.8
NR130118	1	1	2	3	2.2	30	17.2	30.0
NR130098	2	3	3	3	1.7	61	17.4	46.6
NR130157	1	1	2	2	1.6	10	5.4	34.7
NR130148	1	1	2	3	2.2	41	16.4	30.3
NR130134	1	1	3	2	1.5	44	21.2	35.1
NR130126	1	1	3	2	1.3	25	14.8	37.1
NR130040	1	2	2	2	0.9	47	21	28.1
NR130176	1	1	2	2	2.3	68	18	30.2

* Pest/disease ratings where 1: is no symptoms, 5: very severe symptoms

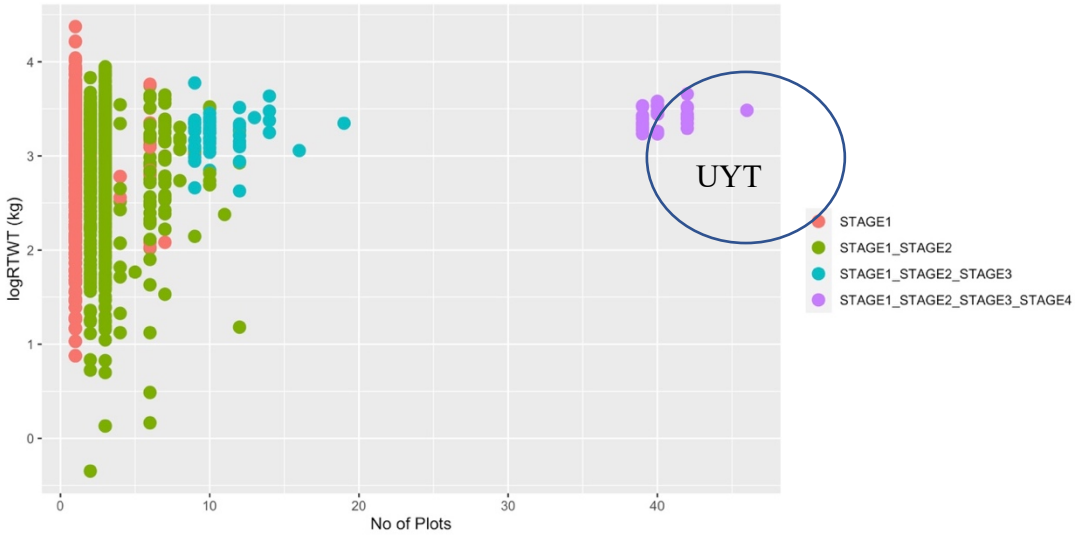
Plant type where 1: very profuse and low branching and 4: erect plant

CBB=cassava bacterial blight; CAD=cassava anthracnose disease; CGM=cassava green mite; FYLD=fresh root yield (t/ha); DMC=dry matter content (%)

Table 3: Promising clones nominated for testing at the National Coordinated Research Project (NCRP).

Clone	*Status*	*Source*
TMS13F1160P0004	Selected Clone	IITA
TMS13F1307P0016	Selected Clone	IITA
TMS13F1343P0022	Selected Clone	IITA
TMS13F1343P0044	Selected Clone	IITA
TMS13F2110P0008	Selected Clone	IITA
TMS13F1020P0001	Selected Clone	IITA
TMS13F1053P0015	Selected Clone	IITA
TMS13F1153P0001	Selected Clone	IITA
IITA-TMS-IBA000070	Selected Clone	IITA
NR130022	Selected Clone	NRCRI
NR130124	Selected Clone	NRCRI
NR14B-218	Selected Clone	NRCRI
NR1741	Selected Clone	NRCRI
NR095F	Selected Clone	NRCRI
NR292D	Selected Clone	NRCRI
Local	Check	
IITA-TMS-IBA30572	National Check	
TMEB419	National Check	

(a)



(b)

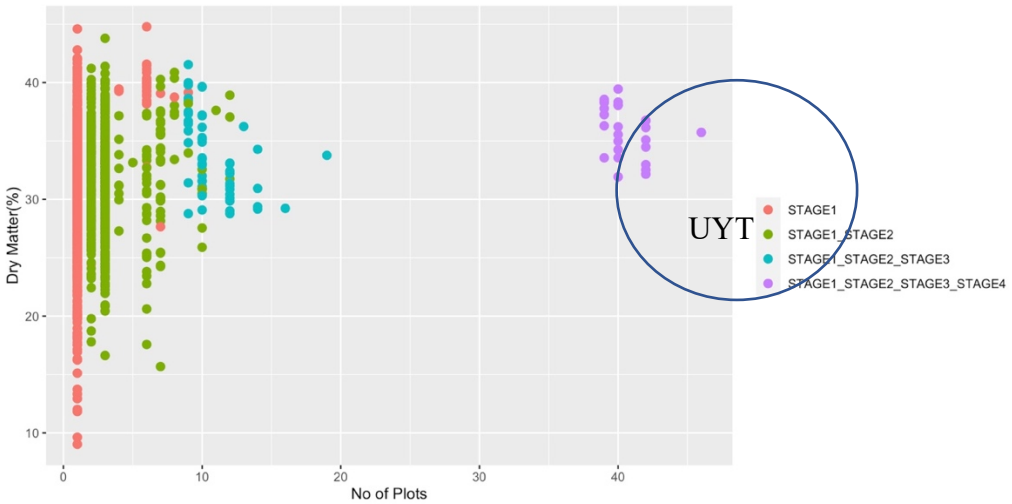


Figure 1: Relative performance of the base population through to various stages of selection and advancement for (a) FYLD and (b) DMC.
(STAGE 1: Seedling evaluation; STAGE 2: Clonal evaluation trial; STAGE 3: Preliminary. yield trial; STAGE 4 Advance yield trial and Uniform yield trial)

Table 4: Estimates of Broad-sense Heritability, genetic variance and coefficient of Variation of 16 trials under which the 34 cassava genotypes were evaluated during the 2016/2017 cropping seasons.

Trial Name	*Location*	*Trait*	*Heritability Est.* (H_m^2)	*Genetic Variance*	*Error Variance*	*Coeff. of Variation*
2017.GS.C1.UYT.34.IKN	Ikenne (Ogun)	DM	0.90	12.852	4.242	6
2017.GS.C1.UYT.34.MOK	Mokwa (Niger)	DM	0.83	12.086	7.24	8
2017.GS.C1.UYT.34.UBJ	Ubiaja (Edo)	DM	0.57	4.137	9.494	8
2017.GS.C1.UYT.34.UMU	Umudike (Abia)	DM	0.83	8.905	5.621	7
2017.GS.C1.UYT.34.IKN	Ikenne (Ogun)	DYLD	0.74	6.692	7.192	21
2017.GS.C1.UYT.34.MOK	Mokwa (Niger)	DYLD	0.76	3.806	3.628	26
2017.GS.C1.UYT.34.UBJ	Ubiaja (Edo)	DYLD	0.44	2.194	8.419	23
2017.GS.C1.UYT.34.UMU	Umudike (Abia)	DYLD	0.50	1.67	5.047	26
2017.GS.C1.UYT.34.IKN	Ikenne (Ogun)	FYLD	0.75	54.573	54.863	20
2017.GS.C1.UYT.34.MOK	Mokwa (Niger)	FYLD	0.72	25.002	29.914	24
2017.GS.C1.UYT.34.UBJ	Ubiaja (Edo)	FYLD	0.56	18.585	43.098	20
2017.GS.C1.UYT.34.UMU	Umudike (Abia)	FYLD	0.55	13.817	34.296	24
2017.GS.C1.UYT.34.IKN	Ikenne (Ogun)	CMD	0.85	0.193	0.106	29
2017.GS.C1.UYT.34.MOK	Mokwa (Niger)	CMD	0.95	0.18	0.031	16
2017.GS.C1.UYT.34.UBJ	Ubiaja (Edo)	CMD	0.98	0.512	0.019	12
2017.GS.C1.UYT.34.UMU	Umudike (Abia)	CMD	0.98	0.548	0.034	15

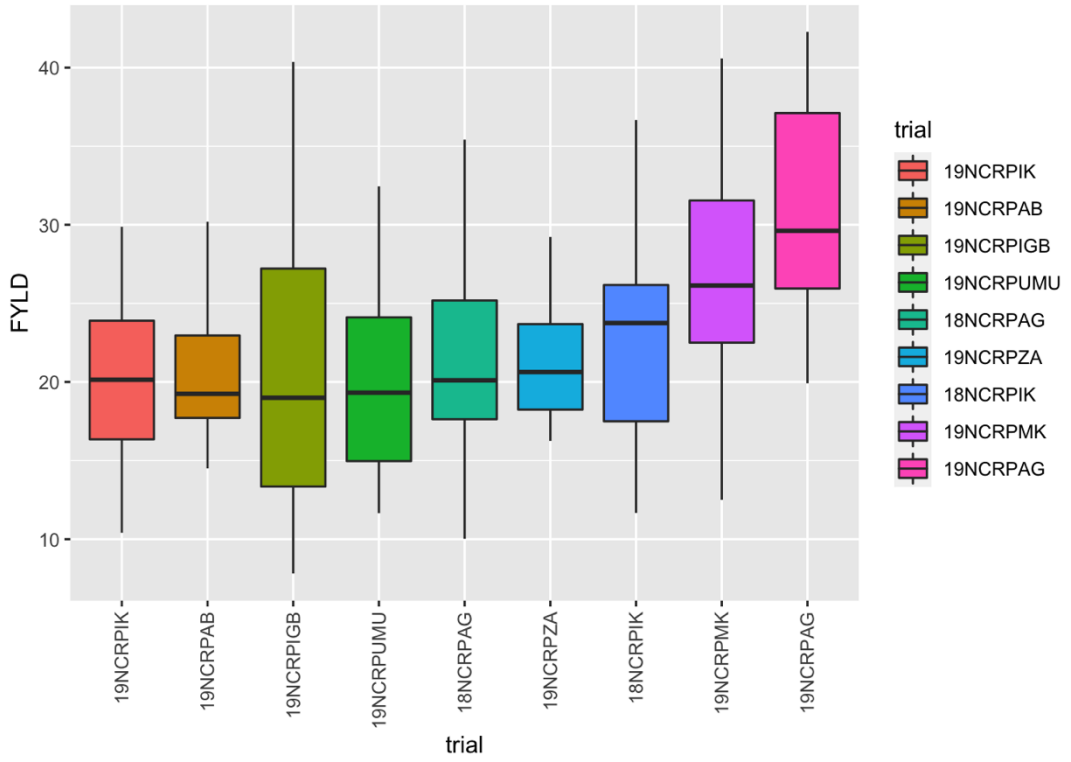
Table 5: Adjusted means of selected traits for 34 cassava genotypes evaluated under multi-location trials at UYT level during the 2016/2017 cropping season. Bolded clones were selected for NCRP.

CLONE	*MEAN CMDS*	*DM %*	*FYLD T/HA*	*DYLD T/HA*	*GARI %*	*FUFU %*	*FUFU FIBRE %*	*SI*
TMS13F1343P0022	**1**	**38**	**34**	**13**	**26**	**21**	**4.4**	**1432.0**
TMS13F1053P0015	**1**	**39**	**33**	**13**	**27**	**24**	**4.0**	**1427.8**
IITA-TMS-IBA000070	**1**	**33**	**37**	**12**	**21**	**18**	**5.8**	**1394.2**
TMS13F1069P0024	3	34	36	12	23	22	3.3	1382.8
TMS13F1160P0004	**1**	**37**	**32**	**12**	**27**	**22**	**0.1**	**1368.6**
TMS13F1377P0018	1	35	33	12	23	20	2.6	1357.8
TMS13F1343P0002	1	36	33	11	23	21	6.0	1350.4
TMS13F1088P0007	1	38	29	11	26	22	9.9	1322.0
TMS13F1365P0002	1	31	36	11	20	16	17.9	1321.8
TMS13F1126P0006	1	33	33	11	24	20	12.9	1296.0
IITA-TMS-IBA980581	1	32	32	11	20	19	6.8	1279.0
TMS13F1343P0013	1	34	30	10	22	16	14.5	1272.2
IITA-TMS-IBA982101	1	30	34	10	21	20	6.0	1271.2
TMS13F1307P0016	**1**	**36**	**28**	**11**	**27**	**22**	**6.5**	**1270.1**
TMS13F1362P0001	1	33	31	10	23	18	10.3	1269.4
TMS13F2110P0008	1	33	31	10	22	18	8.5	1263.0
TMS13F1124P0004	1	31	33	10	20	15	8.1	1260.0
TMS13F1095P0011	1	33	30	10	23	18	9.9	1251.2
TMS13F1153P0001	**1**	**37**	**26**	**10**	**24**	**21**	**9.4**	**1251.2**
TMS13F1176P0002	1	36	27	10	26	22	5.0	1249.4
TMS13F1401P0016	1	31	32	10	20	15	5.8	1240.8
TMS13F1020P0001	1	35	28	10	27	23	1.9	1232.2
TMS13F1053P0009	1	39	23	9	23	19	3.6	1228.2
TMS13F1329P0003	1	32	30	10	22	17	8.0	1227.2
TMS13F1122P0005	3	38	24	9	25	24	1.4	1219.6
TMS13F1343P0044	**1**	**36**	**26**	**9**	**23**	**18**	**10.4**	**1218.0**
TMS13F1365P0029	1	38	23	9	22	16	14.5	1217.0
TMEB419	**1**	**34**	**27**	**9**	**22**	**18**	**9.3**	**1213.2**
TMS13F1063P0013	1	36	24	9	21	19	2.6	1196.8
TMS13F1343P0045	1	38	22	8	22	19	3.9	1193.4
TMS13F1203P0042	1	35	25	9	25	20	2.3	1182.4
TMS13F1288P0005	1	30	29	9	21	16	4.1	1169.6
IITA-TMS-IBA30572	3	30	23	7	17	16	3.6	1021.3
Mean	1	35	30	10				
SEM	0.1	0.5	0.7	0.2				

Table 6: Estimates of Broad-sense Heritability, genetic variance and coefficient of Variation of 16 trials under which the genotypes were evaluated during the 2018/2019 cropping seasons.

Trial name	Environment	Trait	Heritability Est. (H_m^2)	Genetic variance	Error variance	CV
18NCRPAG	Ago-Owu	DM	0.67	3.80	5.65	7
18NCRPIK	Ikenne	DM	0.82	7.98	5.30	7
19NCRPAB	Abuja	DM	0.94	12.82	2.50	5
19NCRPAG	Ago-Owu	DM	0.84	8.39	4.73	6
19NCRPIK	Ikenne	DM	0.94	13.17	2.43	5
19NCRPMK	Mokwa	DM	0.86	14.44	7.31	8
19NCRPZA	Zaria	DM	0.73	2.91	3.26	6
19NCRPIGB	Anambra	DM	0.83	6.45	3.90	5
19NCRPUMU	Umudike	DM	0.64	5.43	9.36	9
18NCRPAG	Ago-Owu	FYLD	0.74	27.92	29.00	24
18NCRPIK	Ikenne	FYLD	0.81	37.27	26.88	23
19NCRPAB	Abuja	FYLD	0.47	8.65	29.40	27
19NCRPAG	Ago-Owu	FYLD	0.42	18.47	76.94	28
19NCRPIK	Ikenne	FYLD	0.86	19.29	9.62	16
19NCRPMK	Mokwa	FYLD	0.85	60.45	32.59	21
19NCRPZA	Zaria	FYLD	0.69	10.91	14.82	18
19NCRPIGB	Anambra	FYLD	0.82	67.70	45.79	34
19NCRPUMU	Umudike	FYLD	0.91	33.45	9.55	15
18NCRPIK	Ikenne	GARI	0.87	7.50	3.44	9
19NCRPAG	Ago-Owu	GARI	0.69	6.05	8.16	14
19NCRPIK	Ikenne	GARI	0.95	12.35	1.80	8
18NCRPAG	Ago-Owu	CMD	0.92	0.63	0.16	33
18NCRPIK	Ikenne	CMD	0.93	0.46	0.11	26
19NCRPAB	Abuja	CMD	0.94	0.10	0.02	12
19NCRPAG	Ago-Owu	CMD	0.88	0.33	0.14	28
19NCRPIK	Ikenne	CMD	0.93	0.16	0.04	16
19NCRPMK	Mokwa	CMD	0.99	0.15	0.01	6
19NCRPZA	Zaria	CMD	0.96	0.04	0.01	7
19NCRPIGB	Anambra	CMD	0.54	0.06	0.16	24
19NCRPUMU	Umudike	CMD	0.83	0.26	0.16	28
18NCRPIK	Ikenne	STARCH	0.79	5.28	4.22	8
19NCRPAG	Ago-Owu	STARCH	0.87	8.15	3.79	7
19NCRPIK	Ikenne	STARCH	0.94	12.09	2.53	6

(a)



(b)

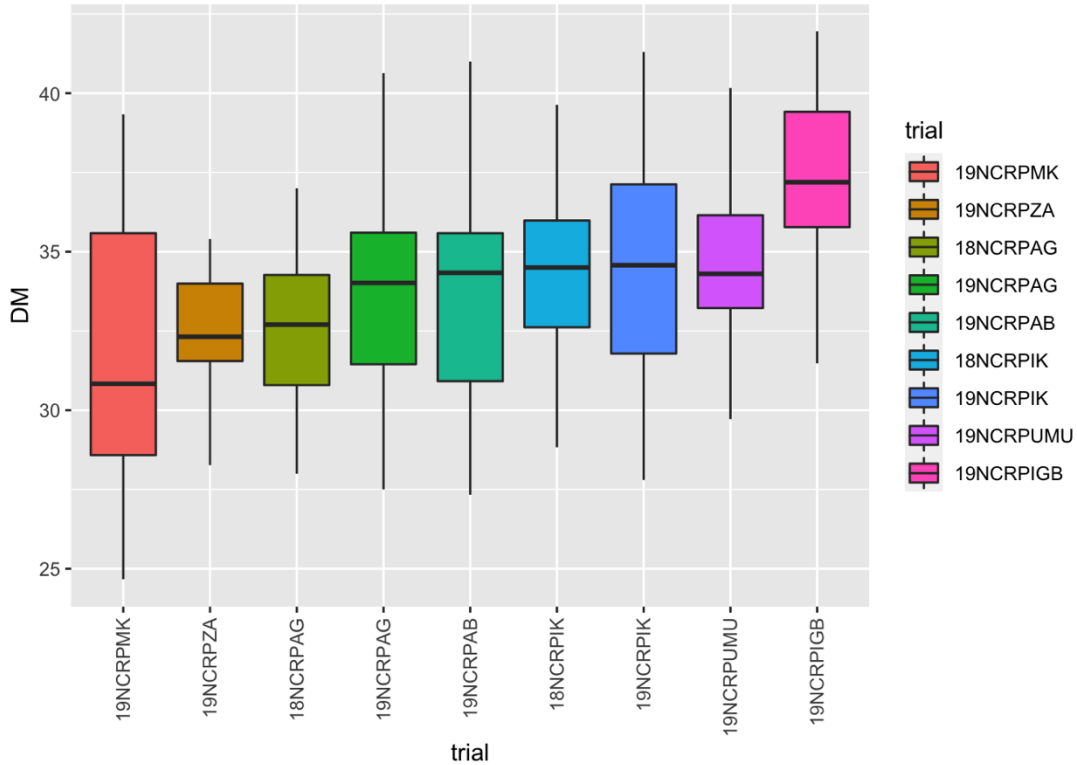


Figure 2: Boxplots showing the variation among and within trial for (A) fresh root yield and (B) dry matter content.

Table 7: Adjusted means for fresh root yield (FYLD) of 18 cassava varieties evaluated under multi-location trials in 2017/2018 and 2018/2019 cropping seasons.

VARIETIES	AGO 18	IKN 18	ABJ 19	AGO 19	IGB 19	IKN 19	MOK 19	UMU 19	ZAR 19	RANK	MEAN	SEM(±)
NR130124	24.8	36.7	23.0	39.3	19.2	29.9	**40.1**	32.5	23.9	1	29.9	2.5
IITA-TMS-IBA000070	18.9	29.4	30.2	**37.5**	29.5	24.6	32.1	31.1	27.5	2	29.0	1.7
TMS13F1343P0044	25.6	25.6	24.4	30.4	**35.3**	23.5	34.9	24.3	29.2	3	28.1	1.5
TMS13F1160P0004	23.7	35.7	22.8	**39.3**	23.3	23.1	29.0	28.9	22.7	4	27.6	2.1
TMS13F1053P0015	31.3	24.6	20.2	28.9	13.4	25.4	40.6	17.4	28.2	5	25.5	2.7
TMS13F1343P0022	27.3	26.4	23.1	26.5	19.0	24.5	**38.7**	19.0	24.5	6	25.4	1.9
NR1741	20.2	24.3	17.8	36.3	30.7	16.7	23.0	23.6	22.9	7	23.9	2.1
TMS13F1307P0016	35.4	23.2	19.6	42.3	10.1	22.5	22.5	19.7	17.2	8	23.6	3.2
TMEB419	17.3	17.5	27.2	27.8	40.4	16.3	26.1	13.3	18.4	9	22.7	2.8
TMS13F1153P0001	25.3	24.5	18.1	25.1	18.5	17.3	28.5	26.0	20.3	10	22.6	1.4
NR095F	10.0	20.8	20.2	34.1	NA	20.8	30.0	22.1	17.2	11	21.9	2.6
TMS13F2110P0008	24.2	16.3	18.9	37.4	13.4	19.5	18.5	20.9	18.2	12	20.8	2.3
NR130022	12.3	15.3	17.7	28.4	27.2	15.4	26.2	18.1	20.2	13	20.1	1.9
TMS13F1020P0001	20.0	28.3	14.7	25.8	12.4	24.0	14.2	14.1	21.0	14	19.4	1.9
IITA-TMS-IBA30572	18.7	17.5	17.7	21.8	12.1	18.4	22.5	18.6	16.3	15	18.2	1.0
NR292D	19.7	20.0	14.5	24.2	7.8	14.4	22.7	13.7	21.3	16	17.6	1.8
NR14B-218	14.8	17.0	17.7	19.9	16.9	15.9	17.6	14.2	17.6	17	16.8	0.6
LOCAL	15.2	11.7	14.8	33.7	19.0	10.4	12.5	11.7	19.5	18	16.5	2.4
MEAN	21.4	23.0	20.1	31.0	20.5	20.1	26.7	20.5	21.4			
SEM(±)	1.5	1.6	1.0	1.6	2.3	1.2	2.0	1.5	0.9			

AGO = Ago-Owu(Osun), IKN = Ikenne(Ogun), ABJ=Abuja(FCT), IGB =Igbariam(Anambra), MOK= Mokwa(Niger), UMU=Umudike(Abia) and ZAR = Zaria(Kaduna). Local represent the best farmer variety in a specific location/environment. Ranking of the candidate varieties done based on the average yet across location.

Table 8: Adjusted means for dry matter content (%) of 18 cassava varieties evaluated under multi-location trials in 2017/2018 and 2018/2019 cropping seasons.

VARIETIES	AGO 18	IKN 18	ABJ 19	AGO 19	IGB 19	IKN 19	MOK 19	UMU 19	ZAR 19	RANK	MEAN	SEM(±)
TMS13F1160P0004	35.7	39.2	41.0	40.6	**42.0**	41.3	39.3	40.2	34.8	1	39.3	0.8
TMS13F1343P0022	37.0	36.0	39.3	37.6	**40.7**	38.5	37.7	35.5	34.9	2	37.5	0.6
TMS13F1053P0015	35.2	39.6	35.3	36.1	37.2	37.6	36.7	39.1	33.4	3	36.7	0.7
NR14B-218	32.5	33.6	38.3	35.2	40.2	34.4	35.7	37.6	34.6	4	35.8	0.8
TMS13F1307P0016	34.3	35.8	35.7	34.5	39.7	39.1	31.7	35.4	32.4	5	35.4	0.9
TMS13F1343P0044	33.1	35.0	34.3	34.1	37.4	33.7	35.0	34.6	35.4	6	34.7	0.4
TMS13F1020P0001	32.9	36.3	34.0	35.7	38.4	35.7	30.7	36.4	31.7	7	34.6	0.8
TMEB419	35.5	34.5	35.3	34.7	39.0	31.5	30.0	33.1	34.1	8	34.2	0.9
NR130022	29.9	32.9	37.3	31.1	36.3	35.1	36.0	35.1	33.8	9	34.2	0.8
IITA-TMS-IBA000070	34.1	32.5	33.7	33.9	**35.8**	34.8	35.3	34.1	32.5	10	34.1	0.4
LOCAL	32.1	36.9	34.7	33.8	39.4	33.9	31.0	30.0	31.5	11	33.7	1.0
TMS13F1153P0001	31.2	34.5	30.3	32.0	36.8	36.2	30.3	36.5	32.2	12	33.3	0.9
NR1741	33.1	30.0	34.3	37.9	34.8	37.5	28.3	30.2	31.8	13	33.1	1.1
TMS13F2110P0008	31.7	35.4	31.7	34.0	37.0	32.8	28.3	33.9	31.9	14	33.0	0.8
NR292D	28.0	29.7	30.7	29.9	33.3	29.4	29.3	33.6	29.4	15	30.4	0.6
IITA-TMS-IBA30572	30.7	28.8	27.3	31.3	34.5	29.6	28.3	31.9	29.7	16	30.2	0.7
NR130124	29.7	**33.2**	28.3	31.0	31.5	28.9	27.7	29.7	31.2	17	30.1	0.6
NR095F	30.0	29.9	30.7	27.5	NT	27.8	24.7	33.7	28.3	18	29.1	0.9
MEAN	32.6	34.1	34.0	33.9	37.3	34.3	32.0	34.5	32.4			
SEM(±)	0.57	0.74	0.87	0.74	0.68	0.89	0.97	0.69	0.47			

AGO = Ago-Owu(Osun), IKN = Ikenne(Ogun), ABJ=Abuja(FCT), IGB =Igbariam(Anambra), MOK= Mokwa(Niger), UMU=Umudike(Abia) and ZAR = Zaria(Kaduna). Local represent the best farmer variety in a specific location/environment. Ranking of the candidate varieties done based on the average yet across location.

Table 9: Adjusted means for dry yield (t/ha) of 18 cassava varieties evaluated under multi-location trials in 2017/2018 and 2018/2019 cropping seasons

VARIETY	AGO 18	IKN 18	ABJ 19	AGO 19	IGB 19	IKN 19	MOK 19	UMU 19	ZAR 19	RANK	Mean	SEM(±)
TMS13F1160P0004	6.79	11.25	5.06	12.71	7.83	8.02	8.68	9.14	6.52	1	8.44	0.79
TMS13F1343P0044	6.77	7.17	6.39	8.27	10.13	6.33	9.88	6.79	8.32	2	7.78	0.48
IITA-TMS-IBA000070	5.11	7.66	7.24	10.13	8.43	6.81	8.25	8.49	7.13	3	7.7	0.46
TMS13F1343P0022	8.02	7.64	6.58	7.96	6.25	7.57	11.13	5.43	6.83	4	7.49	0.54
TMS13F1053P0015	8.86	7.78	5.23	8.31	3.94	7.63	10.42	5.46	7.51	5	7.24	0.67
NR130124	5.83	9.76	4.64	9.73	4.76	6.91	8.46	7.76	6.04	6	7.1	0.65
TMS13F1307P0016	9.73	6.67	5.27	11.78	3.25	6.96	6.24	5.56	4.48	7	6.66	0.88
NR1741	5.36	5.86	4.35	10.86	8.44	5	5.15	5.69	5.92	8	6.29	0.68
TMEB419	4.82	4.84	6.95	7.81	12.57	4.11	6.48	3.45	5.02	9	6.23	0.92
TMS13F1153P0001	6.34	6.65	4.37	6.41	5.46	4.99	7.2	7.6	5.28	10	6.03	0.36
TMS13F2110P0008	6.11	4.61	4.28	10.17	3.96	5.14	4.29	5.65	4.65	11	5.43	0.64
NR130022	2.94	4.03	4.8	7.16	7.87	4.28	6.63	5.08	5.46	12	5.36	0.53
TMS13F1020P0001	5.25	8.3	3.48	7.39	3.8	6.86	3.39	4.11	5.33	13	5.32	0.61
NR095F	2.44	5.16	4.15	7.59	NT	4.59	6.93	5.98	3.88	14	5.09	0.6
NR14B-218	3.89	4.57	4.63	5.65	5.47	4.39	4.66	4.25	4.94	15	4.72	0.19
Local	3.94	3.43	3.83	9.21	5.98	2.84	2.91	2.77	4.91	16	4.43	0.69
IITA-TMS-IBA30572	4.53	3.94	4.18	5.44	3.31	4.35	5.18	4.75	3.85	17	4.39	0.22
NR292D	4.42	4.77	3.22	5.8	2.06	3.4	5.27	3.65	5.08	18	4.19	0.4
Mean	5.62	6.34	4.93	8.47	6.09	5.56	6.73	5.64	5.62			
SEM(±)	0.46	0.51	0.28	0.5	0.68	0.37	0.56	0.41	0.29			

Table 10: Adjusted means for gari percentage of 18 cassava varieties evaluated under multi-location trials in 2017/2018 and 2018/2019 cropping seasons.

GENOTYPE	IKN18	AGO19	IKN19	RANK	MEAN	SEM(±)
TMS13F1160P0004	25.80	23.75	25.34	1	24.96	0.62
TMS13F1343P0022	24.50	25.00	22.55	2	24.02	0.75
NR130124	19.20	26.60	24.40	3	23.53	1.39
TMS13F1020P0001	24.90	21.80	21.30	4	22.67	1.13
TMS13F1053P0015	23.60	23.50	20.60	5	22.57	0.98
TMEB419	25.20	22.45	18.75	6	22.13	1.87
TMS13F1307P0016	23.30	21.25	20.65	7	21.73	0.80
NR1741	22.50	24.40	17.60	8	21.50	2.03
TMS13F1343P0044	21.30	21.85	18.45	9	20.53	1.05
TMS13F2110P0008	23.20	20.10	17.55	10	20.28	1.63
IITA-TMS-IBA000070	21.60	23.35	15.55	11	20.17	2.36
NR14B-218	19.50	22.05	15.30	12	18.95	1.97
TMS13F1153P0001	17.90	18.25	19.80	13	18.65	0.58
LOCAL	21.60	17.35	14.50	14	17.82	2.06
NR130022	17.70	18.80	14.85	15	17.12	1.18
IITA-TMS-IBA30572	20.30	14.35	15.95	16	16.87	1.78
NR095F	18.20	17.85	12.80	17	16.28	1.74
NR292D	14.90	15.95	10.80	18	13.88	1.57
MEAN	21.40	20.48	17.60			
SEM(±)	0.72	0.75	0.87			

AGO = Ago-Owu(Osun), IKN = Ikenne(Ogun), ABJ=Abuja (FCT), IGB =Igbariam (Anambra), MOK= Mokwa (Niger), UMU=Umudike (Abia) and ZAR = Zaria (Kaduna). Local represent the best farmer variety in a specific location/environment. Ranking of the candidate varieties done based on the average yet across location.

Table 11: Adjusted means for fufu percentage of 18 varieties evaluated under multi-location trials in 2017/2018 and 2018/2019 cropping seasons.

GENOTYPE	AGO19	IKN19	RANK	MEAN	SEM(±)
TMS13F1160P0004	25.55	27.20	1	26.38	0.82
TMS13F1343P0022	25.75	25.35	2	25.55	0.20
TMS13F1307P0016	24.20	26.05	3	25.13	0.93
TMS13F1053P0015	23.90	25.60	4	24.75	0.85
TMS13F1020P0001	23.05	25.45	5	24.25	1.20
TMS13F1343P0044	22.35	25.20	6	23.78	1.43
IITA-TMS-IBA000070	24.20	21.40	7	22.80	1.40
NR1741	25.35	19.70	8	22.53	2.83
NR14B-218	24.45	20.30	9	22.38	2.08
TMEB419	22.50	21.75	10	22.13	0.38
TMS13F1153P0001	19.05	24.30	11	21.68	2.63
TMS13F2110P0008	21.70	20.85	12	21.28	0.42
NR095F	18.85	23.65	13	21.25	2.40
NR130022	21.10	NT	14	21.10	0.00
LOCAL	19.75	22.15	15	20.95	1.20
IITA-TMS-IBA30572	20.25	19.80	16	20.03	0.23
NR130124	19.75	19.95	17	19.85	0.10
NR292D	15.75	18.45	18	17.10	1.35
MEAN	22.08	22.77			
SEM(±)	0.65	0.66			

AGO = Ago-Owu(Osun), IKN = Ikenne(Ogun), ABJ=Abuja(FCT), IGB =Igbariam(Anambra), MOK= Mokwa(Niger), UMU=Umudike(Abia) and ZAR = Zaria(Kaduna). Local represent the best farmer variety in a specific location/environment. Ranking of the candidate varieties done based on the average yet across location.

Table 12: Adjusted means for starch content (%) of 18 cassava varieties evaluated under multi-location trials in 2017/2018 and 2018/2019 cropping seasons.

GENOTYPE	IKN18	AGO19	IKN19	RANK	MEAN	SEM(±)
TMS13F1160P0004	29.80	33.23	35.65	1	32.89	1.70
TMS13F1053P0015	29.30	29.37	32.25	2	30.31	0.97
TMS13F1307P0016	25.67	27.47	33.85	3	28.99	2.48
TMS13F1153P0001	27.20	26.67	32.05	4	28.64	1.71
TMS13F1343P0022	27.30	30.03	28.40	5	28.58	0.79
TMEB419	27.60	30.23	27.55	6	28.46	0.89
TMS13F1343P0044	27.37	28.53	28.60	7	28.17	0.40
NR1741	22.53	30.30	31.35	8	28.06	2.78
IITA-TMS-IBA000070	26.30	28.00	29.45	9	27.92	0.91
TMS13F1020P0001	24.37	27.67	30.05	10	27.36	1.65
LOCAL	26.47	26.17	28.25	11	26.96	0.65
NR14B-218	23.80	27.17	28.60	12	26.52	1.42
NR130022	24.37	23.20	29.70	13	25.76	2.00
TMS13F2110P0008	25.00	25.30	26.20	14	25.50	0.36
NR130124	24.43	24.23	24.10	15	24.26	0.10
IITA-TMS-IBA30572	22.40	24.50	24.10	16	23.67	0.64
NR292D	21.37	23.33	25.20	17	23.30	1.11
NR095F	20.67	21.03	21.25	18	20.98	0.17
MEAN	25.33	27.02	28.70			
SEM(±)	0.61	0.72	0.86			

AGO = Ago-Owu(Osun), IKN = Ikenne(Ogun), ABJ=Abuja(FCT), IGB =Igbariam(Anambra), MOK= Mokwa(Niger), UMU=Umudike(Abia) and ZAR = Zaria(Kaduna). Local represent the best farmer variety in a specific location/environment. Ranking of the candidate varieties done based on the average yet across location.

Table 13: Adjusted means for cassava mosaic disease (CMD) severity scores of 18 cassava varieties evaluated under multi-location trials in 2017/2018 and 2018/2019 cropping seasons.

VARIETY	AGO 18	IKN 18	ABJ 19	AGO 19	IKN 19	MOK 19	UMU 19	ZAR 19	MEAN	SEM(±)
IITA-TMS-IBA000070	1	1	1	1	1	1	2	1	1	0.1
IITA-TMS-IBA30572	4	4	2	3	3	3	2	2	3	0.3
LOCAL	3	2	2	2	2	1	2	1	2	0.2
NR095F	1	2	1	1	1	1	2	1	1	0.2
NR130022	1	1	1	1	1	1	2	1	1	0.1
NR130124	1	1	1	1	1	1	1	1	1	0.1
NR14B-218	1	1	1	1	1	1	1	1	1	0.1
NR1741	1	1	1	2	1	1	1	1	1	0.2
NR292D	1	1	1	1	1	1	3	1	2	0.3
TMEB419	1	1	1	2	1	1	2	1	1	0.1
TMS13F1020P0001	1	1	1	1	1	1	1	1	1	0.1
TMS13F1053P0015	1	1	1	1	1	1	1	1	1	0.1
TMS13F1153P0001	1	1	1	1	1	1	2	1	1	0.1
TMS13F1160P0004	1	1	1	1	1	1	1	1	1	0.1
TMS13F1307P0016	1	1	1	1	1	1	1	1	1	0.0
TMS13F1343P0022	1	1	1	1	1	1	1	1	1	0.1
TMS13F1343P0044	1	1	1	1	1	1	1	1	1	0.1
TMS13F2110P0008	1	1	1	1	1	1	1	1	1	0.1
MEAN	1	1	1	1	1	1	1	1		
SEM(±)	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1		

Cassava mosaic disease (CMD) was scored based on a five-point scale (where 1=highly resistant, 2= moderately resistant, 3=tolerant, 4=susceptible and 5=highly susceptible)

Table 1: Adjusted means for Cassava Bacterial Blight (CBB) severity scores of 18 cassava varieties evaluated under multi-location trials in 2017/2018 and 2018/2019 cropping seasons.

Genotype	*ABJ 19*	*AGO 19*	*IGB 19*	*IKN 19*	*MOK 19*	*UMU 19*	*ZAR 19*	*Mean*	*SEM(±)*
IITA-TMS-IBA000070	1	2	2	2	3	2	2	2	0.2
IITA-TMS-IBA30572	2	2	2	2	3	2	3	2	0.18
Local	2	2	2	2	4	2	3	2	0.3
NR095F	2	2	-	2	3	2	3	2	0.29
NR130022	1	2	2	2	3	2	2	2	0.2
NR130124	1	2	2	2	3	2	2	2	0.24
NR14B-218	2	2	3	2	3	2	2	2	0.21
NR1741	2	2	3	2	3	2	2	2	0.21
NR292D	1	2	2	2	3	2	2	2	0.23
TMEB419	2	2	2	2	3	3	2	2	0.28
TMS13F1020P0001	1	2	2	2	3	3	2	2	0.31
TMS13F1053P0015	2	2	2	2	3	3	2	2	0.22
TMS13F1153P0001	2	2	3	2	3	3	2	2	0.22
TMS13F1160P0004	2	2	3	2	3	2	2	2	0.24
TMS13F1307P0016	1	2	2	2	3	2	2	2	0.21
TMS13F1343P0022	1	2	2	2	3	2	1	2	0.22
TMS13F1343P0044	2	2	3	2	3	2	2	2	0.19
TMS13F2110P0008	2	2	2	2	3	2	3	2	0.22
Mean	2	2	2	2	3	2	2		
SEM(±)	0.09	0.01	0.08	0	0.06	0.12	0.11		

The mean Cassava Bacterial Blight (MCBB) was scored based on a five-point scale (where 1=highly resistant, 2= moderately resistant, 3=tolerant, 4=susceptible and 5=highly susceptible),

Table 2: Adjusted means for Cassava Green Mite (MCGM) severity scores of 18 cassava varieties evaluated under multi-location trials in 2017/2018 and 2018/2019 cropping seasons.

Genotype	*AGO 18*	*IKN 18*	*ABJ 19*	*AGO 19*	*IKN 19*	*ZAR 19*	*Mean*	*SEM(±)*
IITA-TMS-IBA000070	2	2	3	3	3	1	2	0.35
IITA-TMS-IBA30572	3	2	4	4	3	1	3	0.48
Local	2	2	3	3	2	1	2	0.22
NR095F	3	2	4	4	4	1	3	0.46
NR130022	3	2	4	4	4	1	3	0.45
NR130124	2	2	3	3	3	1	3	0.34
NR14B-218	2	2	3	3	3	1	2	0.42
NR1741	2	2	4	3	4	1	3	0.48
NR292D	2	2	3	3	3	1	3	0.35
TMEB419	2	2	4	3	3	1	3	0.4
TMS13F1020P0001	2	2	4	3	3	1	3	0.34
TMS13F1053P0015	3	3	4	3	3	1	3	0.38
TMS13F1153P0001	3	2	4	3	3	1	3	0.32
TMS13F1160P0004	3	2	3	3	3	2	3	0.27
TMS13F1307P0016	2	2	4	3	3	1	3	0.42
TMS13F1343P0022	2	2	4	3	3	2	3	0.28
TMS13F1343P0044	3	2	3	3	3	1	3	0.33
TMS13F2110P0008	2	2	4	4	4	1	3	0.46
Mean	2	2	4	3	3	1		
SEM(±)	0.09	0.06	0.08	0.1	0.11	0.05		

Mean Cassava Green mite (MCGM) infestation was scored based on a five-point scale (where 1=highly resistant, 2= moderately resistant, 3=tolerant, 4=susceptible and 5=highly susceptible)

Table 36: GGE ANOVA table for fresh yield (FYLD), dry matter content (DMC) and dry yield (DYLD) from the NCRP trials.

Source of Variation	**Mean Square**			
	Df	**FYLD**	**DMC**	**DYLD**
Environment	8	249.4***	44.015***	18.881***
Interactions	*153*	*42.445*	*10.042*	*3.810*
PC1	24	124.831***	45.773***	11.774***
PC2	22	72.863***	5.683*	6.317***
Residuals	107	17.711	2.924	1.508

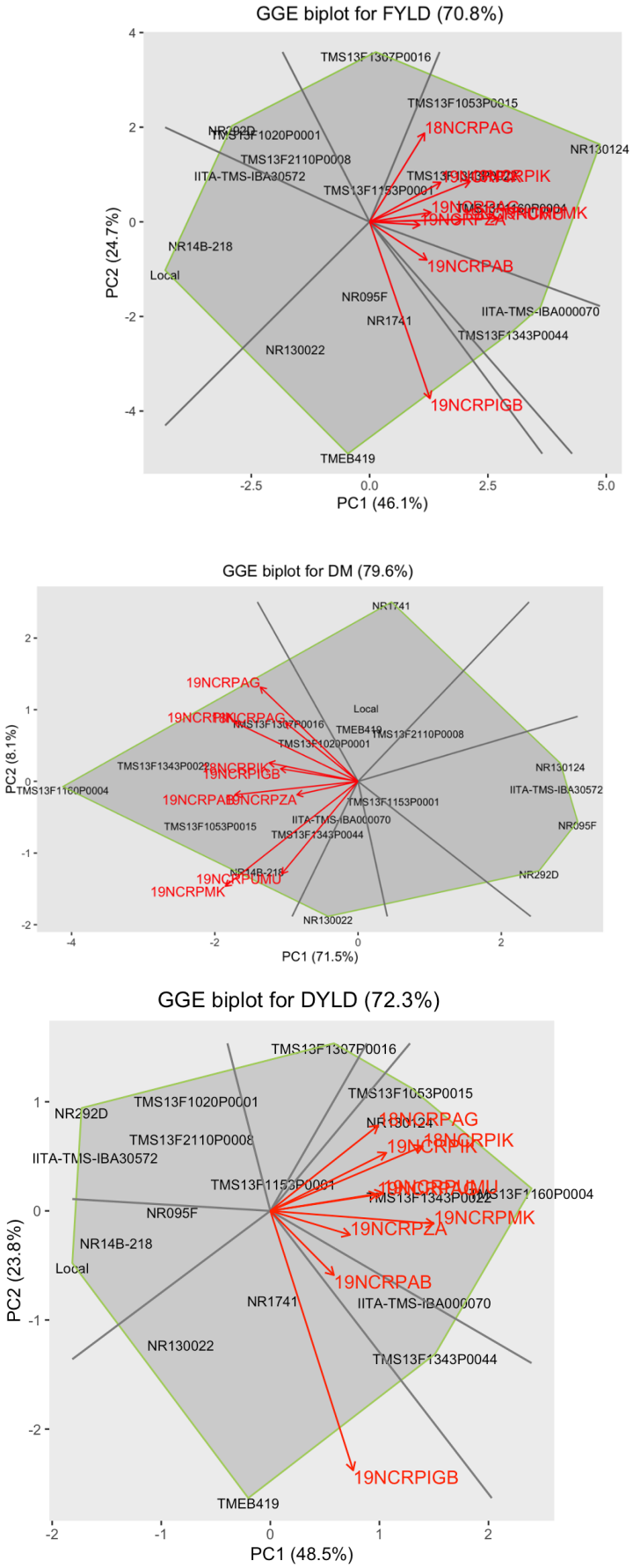


Figure3: GGE biplot for fresh root yield (FYLD), dry matter content (DMC) and dry yield (DYLD) in among 18 varieties in multi-environment trials.

Table 17: A List of selected states used for on-farm evaluation of these multi-purpose cassava varieties in Nigeria.

STATE	AGRO-ECOLOGICAL ZONE	NO OF ON-FARM TRIALS
DELTA	Rainforest	3
ONDO	Rainforest	3
EDO	Southern Guinea Savanna	4
IMO	Northern Guinea Savanna	3
JIGAWA	Derived Savanna	4
KADUNA	Derived Savanna	4
KOGI	Southern Guinea Savanna	4
BENUE	Southern Guinea Savanna	3
KWARA	Derived Savanna	3
NIGER	Derived Savanna	4

Table 18: Fresh root yield (t/ha) of cassava varieties evaluated under on-farm trials in some states of Nigeria during the 2019/2020 cropping seasons.

STATE	IITA-TMS-IBA00070	LOCAL	NR130124	TMEB419	TMS13F1160 P0004	TMS13F1307 P0016	TMS13F1343 P0022	TMS13F1343 P0044
DELTA	19.81(NT)	22.81(NT)	16(NT)		25.81(NT)	19.63(NT)	5.96(NT)	7.19(NT)
EDO	26.9(4)	17.82(7)	17.9(4)	7.3(5)	10.73(1)	12.02(5)	13.73(3)	19.83(3)
IMO	20.63(1)		17.71(3)		17.13(1)	17.38(4)	14.08(5)	13.79(6)
JIGAWA	22.91(4)	12.2(7)	11.39(5)		16.41(1)	13.2(5)	12.61(3)	15.86(3)
KADUNA	24.19(4)	14.03(7)	19.84(4)		22.31(2)	18.41(5)	19.72(2)	19.19(4)
KOGI	32.08(4)	9.01(6)	32.15(5)	18.73(4)	17.51(1)		13.81(3)	21.9(4)
KWARA	**40.1(4)**	16.93(7)	31.29(5)	36.7(2)	31.02(1)	38.18(5)	34.33(3)	37.39(5)
NIGER	36.69(3)	30.09(7)	29.56(5)		20.47(1)	27.59(5)	22.61(3)	30.46(3)
OGUN	20.61(3)	12.91(7)	10.97(4)		23(1)	21.28(5)	14.09(3)	11.29(4)
ONDO	23.56(4)	6.37(7)			14.17(1)	23.05(5)	25.63(2)	3.89(4)
MEAN	26.75(3.8)	15.8(6.8)	20.76(4.7)	20.91(3.7)	19.86(1.2)	21.19(4.8)	17.66(2.7)	18.08(3.6)

The figures in parenthesis is the rank on a scale of 1–7; where 1 = most preferred and 7 = least preferred; N.T = Not tested;
* = mean ranking

Table 19: Dry matter content (%) of cassava varieties evaluated under on-farm trials in some states of Nigeria during the 2019/2020 cropping seasons.

State	IITA-TMS-IBA00070	Local	NR130124	TMEB419	TMS13F1160 P0004	TMS13F1307 P0016	TMS13F1343 P0022	TMS13F1343 P0044
Delta	33.78(NT)	30.82(NT)	30.7(NT)	-	41.98(NT)	36.48(NT)	39.8(NT)	37.28(NT)
Edo	37.67(4)	23.11(7)	34.2(4)	47.18(5)	42.93(1)	39.5(5)	42.13(3)	40.27(3)
Imo	35.42(1)	-	37.47(3)	-	44.14(1)	40.99(4)	41.44(5)	34.77(6)
Jigawa	35(4)	25.2(7)	36.2(5)	-	44.83(1)	37.64(5)	40.3(3)	39.58(3)
Kaduna	40.5(4)	36.2(7)	40.65(4)	-	47.34(2)	35.89(5)	43.7(2)	43.3(4)
Kogi	38.73(4)	41.52(6)	38.8(5)	43.76(4)	41.66(1)	-	42.17(3)	40.33(4)
Kwara	39.4(4)	41.46(7)	38.73(5)	43.78(2)	46.06(1)	43.16(5)	43.57(3)	42.9(5)
Niger	36.58(3)	34.63(7)	35(5)	-	43.48(1)	39.48(5)	41.91(3)	36.01(3)
Ogun	37.5(3)	36.21(7)	35.21(4)	-	43.7(1)	40.33(5)	43.1(3)	40.94(4)
Ondo	41.33(4)	32.36(7)		-	46.4(1)	41.88(5)	43.1(2)	38.13(4)
Mean	37.59(3.8)	33.5(6.8)	36.33(4.7)	44.91(3.7)	44.25(1.2)	39.48(4.8)	42.12(2.7)	39.35(3.6)

The figures in parenthesis is the rank on a scale of 1–7; where 1 = most preferred and 7 = least preferred; N.T = Not tested; * = mean ranking

Table 20: Gari quality assessment of cassava varieties of pre-release trials in some states of Nigeria during during the 2019/2020 cropping seasons.

STATE	IITA-TMS-IBA00070	LOCAL BEST	NR130124	TMS13F1160 P0004	TMS13F1307 P0016	TMS13F1343 P0022	TMS13F1343 P0044	MEAN
EDO	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
IMO	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)
JIGAWA	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
KADUNA	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
KOGI	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
KWARA	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
NIGER	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
OGUN	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
ONDO	V. Good (1)	V. Good (2)		V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
MEAN*	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)

The figures in parenthesis is the rank on a scale of 1–7; where 1 = most preferred and 7 = least preferred; * = mean ranking

Table 21: Fufu and lafun quality assessment of cassava varieties of pre-release trials in some states of Nigeria during the 2019/2020 cropping seasons.

STATE	IITA-TMS-IBA00070	LOCAL BEST	NR130124	TMS13F1160 P0004	TMS13F1307 P0016	TMS13F1343 P0022	TMS13F1343 P0044	MEAN
JIGAWA	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
KADUNA	V. Good (1)		V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
KOGI	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
KWARA	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
ONDO	V. Good (1)	V. Good (2)		V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)
MEAN*	V. Good (1)	V. Good (2)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)	V. Good (1)

The figures in parenthesis is the rank on a scale of 1–7; where 1 = most preferred and 7 = least preferred; * = mean ranking

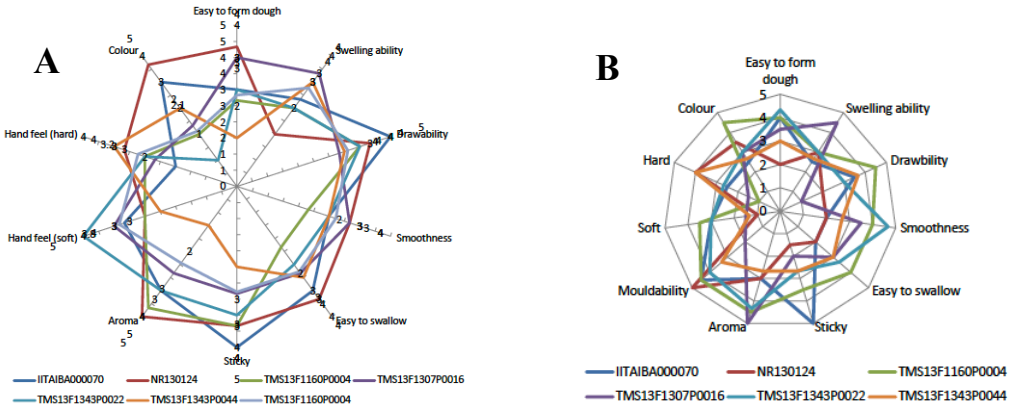


Figure 4. Radar chart of (A) Gari and (B) Fufu for multiple characteristics for the products. On a scale of 1-5, where 1: Least Preferred and 5: Most Preferred.

Table 22: Distinguishing characteristics of the candidate cassava varieties.

TMS13F1160P0004	**TMS13F1343P0022**	**NR130124**	**TMS-IBA00070**
UMUCASS 47	**UMUCASS 48**	**UMUCASS 49**	**UMUCASS 50**
GAME CHANGER	**OBASANJO-2**	**HOPE**	**BABA-70**
INDUSTRY (STARCH)	**INDUSTRY (FLOUR)**	**GARI/FUFU**	**GARI/FUFU**
Very High Dry Matter and High Yield	Very High Dry Matter and High Yield	High Dry Matter and Very High Yield	High Dry Matter and Very High Yield
Brown stem	Silver-brown	Brown stem	Light Brown stem
Profuse Branching	Moderate Top Branching	Profuse Branching	Moderate Top Branching
High Yielding and Broadly Adapted	High Yielding and Broadly Adapted	High Yielding and Broadly Adapted	High Yielding and Broadly Adapted
Very Suitable for Gari and Fufu	Very Suitable for Gari and Fufu	Very Suitable for Gari and Fufu	Very Suitable for Gari and Fufu
Very suitable for High quality Flour	Very suitable for High quality Flour	Moderately Suitable for High quality Flour	Moderately Suitable for High quality Flour
100% Sprouting Ability	100% Sprouting Ability	100% Sprouting Ability	100% Sprouting Ability

Table 23: Profile of agronomic and root quality of the candidate cassava varieties.

Traits	**TMS13F1160P0004**	**TMS13F1343P0022**	**NR130124**	**TMS-IBA00070**
	UMUCASS 47	**UMUCASS 48**	**UMUCASS 49**	**UMUCASS 50**
	GAME CHANGER	**OBASANJO-2**	**HOPE**	**BABA-70**
	INDUSTRY (STARCH)	**INDUSTRY (FLOUR)**	**GARI/FUFU**	**GARI/FUFU**
Fresh yield (t/ha)	42.0	38.7	40.1	37.5
Dry matter (%)	39.2	40.7%	33.2	38.5
Starch (%)	32.89	28.58	24.26	27.92
Gari yield (%)	25.96	24.02	23.53	22.7
Fufu yield (%)	26.38	25.55	19.85	22.8
Plant type	Compact	Umbrella	Compact	Umbrella
Leaf colour	Light green	Dark green	Light green	Dark green
Petiole colour	Red	Greenish purple	Red	Red
Stem colour	Brown	Sliver brown	Brown	Light brown

TSC DESCRIPTORS FORMAT FOR CASSAVA VARIETIES

GENERAL DESCRIPTORS FOR VARIETY TMS13F1160P0004 (GAME CHANGER)

1.	**Species:**	*Manihot esculenta* Crantz.
2.	**Name of variety:**	UMUCASS 47 (GAME CHANGER)
3.	**Old name:**	TMS13F1160P0004
4.	**Origin/Source of variety:**	International Institute of Tropical Agriculture (IITA), Nigeria.
5.	**Type of variety:**	Single cross hybrid
6.	**Pedigree:**	IITA-TMS-IBA993073/IITA-TMS-IBA051740
7.	**Name and address of developing/releasing organizations:**	
	a) Developing Organizations:	International Institute of Tropical Agriculture (IITA), Nigeria / National Root Crops Research Institute (NRCRI), Umudike, Nigeria.
	b) Releasing Organization:	National Root Crops Research Institute (NRCRI), Umudike, Nigeria
	c) Breeders:	Peter Kulakow, Alfred Dixon, Ismail Rabbi, Elizabeth Parkes, Njoku Damian and Chiedozie N. Egesi,
	d) Collaborating scientists:	Busie Maziya-Dixon, Bela Teeken, Tessy Madu, Ugo Chijioke,
8.	**Morphological characteristics:**	Compact branching pattern
9.	**Adaptation:**	Rainforest and Southern Guinea Savannah
10.	**Days to maturity:**	10 – 12 months
11.	**Potential root yield:**	39.2 t/ha
12.	**Pest/Disease tolerance:**	Resistant to cassava mosaic disease (CMD), cassava anthracnose disease (CAD); cassava mealybug (CM); cassava bacterial blight (CBB), cassava green mite (CGM).
13.	**Outstanding characteristics:**	High starch, dry matter content and high fresh root yield.
14.	**Nutrient content:**	Dry matter content (42.0%); Starch (32.9%)
15.	**Year of release:**	

SPECIFIC DESCRIPTORS

1.	**Plant Type:**	Tall (1.73 – 2.52 m)
2.	**Branching habit:**	Profuse branching
3.	**Height at branching:**	(0.39 -0.50 m)
4.	**Suitability for mixed cropping:**	Moderately suitable
5.	**Colour of unexpanded young leaf:**	Green
6.	**First fully expanded leaf colour:**	Dark green
7.	**Pubescence of young leaf:**	None
8.	**Central leaf lobe shape:**	Lanceolate
9.	**Petiole colour:**	Red
10.	**Young stem colour:**	Green
11.	**Stem colour:**	Brown
12.	**Flower:**	Present
13.	**Root neck length:**	Medium
14.	**Outer root skin colour:**	Dark brown
15.	**Inner root skin colour:**	White
16.	**Pulp colour:**	White
17.	**Cyanogenic potential (CNP):**	26.3 mg HCN eqv. per 100 g
18.	**Dry matter of fresh roots (%):**	42.0
19.	**Starch of dried roots (%):**	78.8
20	**Gari yield (%)**	24.96
21	**Proximate composition of dry roots**	Reducing sugar (3.9%); Ash (1.9%); Amylose (29.2%); Amylopectin (70.8%)

UMUCASS 47: TMS13F1160P0004 (GAME CHANGER)

GENERAL DESCRIPTORS FOR VARIETY TMS13F1343P0022 (OBASANJO-2)

1.	**Species:**	*Manihot esculenta* Crantz.
2.	**Name of variety:**	UMUCASS 48 (OBASANJO-2)
3.	**Old name:**	TMS13F1343P0022
4.	**Origin/Source of variety:**	International Institute of Tropical Agriculture (IITA), Nigeria.
5.	**Type of variety:**	Single cross hybrid
6.	**Pedigree:**	IITA-TMS-IBA970425/IITA-TMS-IBA930007
7.	**Name and address of developing/releasing organizations:**	
	a) Developing Organizations:	International Institute of Tropical Agriculture (IITA), Nigeria / National Root Crops Research Institute (NRCRI), Umudike, Nigeria.
	b) Releasing Organization	National Root Crops Research Institute (NRCRI), Umudike, Nigeria
	c) Breeders:	Peter Kulakow, Alfred Dixon, Ismail Rabbi, Elizabeth Parkes, Njoku Damian and Chiedozie N. Egesi
	d) Collaborating scientists:	Busie Maziya-Dixon, Bela Teeken, Tessy Madu, Ugo Chijioke
8.	**Morphological characteristics:**	Umbrella plant with top branching pattern
9.	**Adaptation:**	Rainforest and Southern Guinea Savannah
10.	**Days to maturity:**	10 – 12 months
11.	**Potential root yield:**	38.7 t/ha
12.	**Pest/Disease tolerance:**	Resistant to cassava mosaic disease (CMD), cassava anthracnose disease (CAD); cassava mealybug (CM); cassava bacterial blight (CBB), cassava green mite (CGM).
13.	**Outstanding characteristics:**	High starch, dry matter content and high fresh root yield and good for flour.
14.	**Nutrient content:**	Dry matter content (40.7%); Starch (28.6%)
15.	**Year of release:**	

SPECIFIC DESCRIPTORS

1.	**Plant Type:**	Tall (1.55 – 2.50 m)
2.	**Branching habit:**	Moderately top branching
3.	**Height at branching:**	(0.57 -1.20 m)
4.	**Suitability for mixed cropping:**	Highly suitable
5.	**Colour of unexpanded young leaf:**	Green
6.	**First fully expanded leaf colour:**	Dark green
7.	**Pubescence of young leaf:**	None
8.	**Central leaf lobe shape:**	Lanceolate
9.	**Petiole colour:**	Greenish purple
10.	**Young stem colour:**	Green
11.	**Stem colour:**	Silver-brown
12.	**Flower:**	Present
13.	**Root neck length:**	Medium
14.	**Outer root skin colour:**	Dark brown
15.	**Inner root skin colour:**	White
16.	**Pulp colour:**	White
17.	**Cyanogenic potential (CNP):**	55.8 mg HCN eqv. per 100 g
18.	**Dry matter of fresh roots (%):**	40.7
19.	**Starch of dried roots (%):**	74.5
20	**Gari yield (%)**	24.02
21	**Proximate composition of dry roots**	Reducing sugar (4.2%); Ash (1.6%); Amylose (30.1%); Amylopectin (69.9%)

UMUCASS 48: TMS13F1343P0022 (OBASANJO-2)

GENERAL DESCRIPTORS FOR VARIETY NR130124 (HOPE)

1.	**Species:**	*Manihot esculenta* Crantz.
2.	**Name of variety:**	UMUCASS 49 (HOPE)
3.	**Old name:**	NR130124
4.	**Origin/Source of variety:**	National Root Crops Research Institute (NRCRI), Nigeria.
5.	**Type of variety:**	Single cross hybrid
6.	**Pedigree:**	IITA-TMS-IBA980581/IITA-TMS-IBA980505
7.	**Name and address of developing/releasing organizations:**	
	a) Developing Organization:	National Root Crops Research Institute (NRCRI), Umudike, Nigeria / International Institute of Tropical Agriculture (IITA), Nigeria
	b) Releasing Organization	National Root Crops Research Institute (NRCRI), Umudike, Nigeria
	c) Breeders:	Chiedozie N. Egesi, Damian Njoku, L. Jiwuba, Peter Kulakow, Ismail Rabbi, and Elizabeth Parkes
	d) Collaborating scientists:	Joseph Onyeka, Tessy Madu, Ugo Chijioke, Bela Teeken,
8.	**Morphological characteristics:**	Compact branching pattern
9.	**Adaptation:**	Rainforest and Southern Guinea Savannah
10.	**Days to maturity:**	10 – 12 months
11.	**Potential root yield:**	40.1 t/ha
12.	**Pest/Disease tolerance:**	Resistant to cassava mosaic disease (CMD), resistant to cassava anthracnose disease (CAD); resistant to cassava mealybug (CM); moderately resistant to cassava bacterial blight (CBB), tolerant to cassava green mite (CGM).
13.	**Outstanding characteristics:**	High fresh root yield. Excellent gari and fufu quantity and quality
14.	**Nutrient content:**	Dry matter content (33.2%); Starch (24.3%)
15.	**Year of release:**	

SPECIFIC DESCRIPTORS

1.	**Plant Type:**	Tall (1.69 – 2.0 m)
2.	**Branching habit:**	Profuse branching
3.	**Height at branching:**	(0.35 -0.50 m)
4.	**Suitability for mixed cropping:**	Moderately suitable
5.	**Colour of unexpanded young leaf:**	Green
6.	**First fully expanded leaf colour:**	Dark green
7.	**Pubescence of young leaf:**	None
8.	**Central leaf lobe shape:**	Lanceolate
9.	**Petiole colour:**	Red
10.	**Young stem colour:**	Purple
11.	**Stem colour:**	Purple
12.	**Flower:**	Present
13.	**Root neck length:**	Medium
14.	**Outer root skin colour:**	Light brown
15.	**Inner root skin colour:**	White
16.	**Pulp colour:**	White
17.	**Cyanogenic potential (CNP):**	31.8 mg HCN eqv. per 100 g
18.	**Dry matter of fresh roots (%):**	33.2
19.	**Starch of dried roots (%):**	65.2
20	**Gari yield (%)**	23.53
21	**Proximate composition of dry roots**	Reducing sugar (4.4%); Ash (2.3%); Amylose (29.4%); Amylopectin (70.6%);

UMUCASS 49: NR130124 (HOPE)

GENERAL DESCRIPTORS FOR VARIETY IITA-TMS-IBA00070 (BABA-70)

1.	**Species:**	*Manihot esculenta* Crantz.
2.	**Name of variety:**	UMUCASS 50 (BABA-70)
3.	**Old name:**	IITA-TMS-IBA00070
4.	**Origin/Source of variety:**	International Institute of Tropical Agriculture (IITA), Nigeria.
5.	**Type of variety:**	Hybrid
6.	**Pedigree:**	TMEB459 half-sib
7.	**Name and address of developing/releasing organizations:**	
	a) Developing Organization:	International Institute of Tropical Agriculture (IITA), Nigeria / National Root Crops Research Institute (NRCRI), Umudike, Nigeria.
	b) Releasing Organization	National Root Crops Research Institute (NRCRI), Umudike, Nigeria
	c) Breeders:	Peter Kulakow, Alfred Dixon, Ismail Rabbi, Elizabeth Parkes, Njoku Damian and Chiedozie N. Egesi,
	d) Collaborating scientists:	Busie Maziya-Dixon, Bela Teeken, Tessy Madu, Ugo Chijioke
8.	**Morphological characteristics:**	Umbrella plant with top branching pattern
9.	**Adaptation:**	Rainforest and Southern Guinea Savannah
10.	**Days to maturity:**	10 – 12 months
11.	**Potential root yield:**	37.5 t/ha
12.	**Pest/Disease tolerance:**	Resistant to cassava mosaic disease (CMD), cassava anthracnose disease (CAD); cassava mealybug (CM); cassava bacterial blight (CBB), cassava green mite (CGM).
13.	**Outstanding characteristics:**	High fresh root yields. Excellent gari and fufu quality.
14.	**Nutrient content:**	Dry matter content (38.5%); Starch (28.0%)
15.	**Year of release:**	

SPECIFIC DESCRIPTORS

1.	**Plant Type:**	Tall (1.8 – 2.5 m)
2.	**Branching habit:**	Moderately Top branching
3.	**Height at branching:**	(0.62 – 1.50 m)
4.	**Suitability for mixed cropping:**	Moderately suitable
5.	**Colour of unexpanded young leaf:**	Green
6.	**First fully expanded leaf colour:**	Dark green
7.	**Pubescence of young leaf:**	None
8.	**Central leaf lobe shape:**	Lanceolate
9.	**Petiole colour:**	Red
10.	**Young stem colour:**	Green
11.	**Stem colour:**	Light brown
12.	**Flower:**	Present
13.	**Root neck length:**	Medium
14.	**Outer root skin colour:**	Light brown
15.	**Inner rootskin colour:**	White
16.	**Pulp colour:**	White
17.	**Cyanogenic potential (CNP):**	53.2 mg HCN eqv. per 100 g
18.	**Dry matter of fresh roots (%):**	38.5
19.	**Starch of dried roots (%):**	68.5
20	**Gari yield (%)**	20.17
21	**Proximate composition of dry roots**	Reducing sugar (4.7%); Ash (2.1%); Amylose (28.6%); Amylopectin (71.3%)

UMUCASS 50: IITA-TMS-IBA00070 (BABA-70)